System Restoration Strategy
PJM/Monitoring Analytics Draft Proposal
Revised 12/14/12

Design Component #1 – Restoration Time (Target)

PJM has shown analysis that indicates the current 24 hour restoration target time is not achievable given the assumptions of a complete blackout with no outside assistance. Further analysis indicates that even in an optimal hypothetical situation in which all units are Black Start capable; a 24 hour system restoration is unlikely. Transmission Owners may elect to include System Restoration time estimates for their zone in their individual restoration plans, if desired.

For these reasons, **PJM proposes to eliminate time targets from Manual M-36 (Section 3.1, Attachment A) and M-12 (Section 4.6.6)**. PJM will replace the time references with the following statement:

*A system assessment following a blackout is a critical first step in identifying an overall system restoration time. While PJM and its Members work to restore the integrity to the interconnection as quickly as possible, there are a wide variety of factors that can influence a system restoration. Once the system conditions following a blackout are known, estimates of restoration times of the Bulk Electric System (BES) transmission and customer load restoration estimates can more accurately be made.*

PJM has begun taking this proposed change to Manual 36 through the committee process (SOS, OC, MRC) in the November/December meetings.

Design Component #2 – Redundancy

PJM recognizes the need for some redundancy in Black Start generation. This redundancy allows for system restoration even when some Black Start resources are unavailable when needed and for imprecise nature of Critical Load calculations. This redundancy can be accomplished in different ways including adding a “buffer” on the Critical Load calculation which in turn should result in a higher amount of Black Start capability than should be required for Critical Load. Another method of ensuring redundancy is to require a minimum number of Black Start resources within a defined restoration area.

PJM recommends the following actions to achieve redundancy:

1) **Add a “buffer” of 10% of Critical load to the Black Start requirement.** This will account for an average forced outage rate (5%) plus an allowance for additional, unexpected Critical Load (5%).

2) **Ensure a minimum of two Black Start resources are “allocated” to each transmission zone with a Critical Load requirement.** Note that the Black Start resources are not required to be physically located within the zone to which they are allocated. However, each zone must be able to identify within their System
Restoration plan the two resources allocated to them during a System Restoration. Exceptions to this “two resource rule” will be allowed with PJM and System Operation Subcommittee-Transmission (SOS-T) approval. In some cases, the same Black Start resource may be used to serve critical load in multiple TO zones if it has the capacity available to do so. Upon full aggregation of TO Restoration Plans into new Restoration “zone”, redundancy will be measured based on the redefined area (see Cross Zonal coordination section below)

Design Component #3 – Cross Zonal Coordination

PJM recommends a proactive approach to identifying areas of the system where it would be beneficial to coordinate Transmission Owner (TO) Restoration plans. PJM would work with the TOs to identify areas in the RTO where it would make sense to coordinate System Restoration plans based on:

- Reliability requirements including:
  - Meeting critical load requirements
  - Meeting critical load restoration timing requirements
  - Redundancy requirements

- Technical feasibility requirements including:
  - Maintaining voltages within limits
  - Maintaining MW flows within thermal limits
  - Maintaining dynamic stability of generation
  - Timing requirements of serving critical load
  - Test history and performance history of Black Start unit

- Complexity considerations
  - Amount of switching to establish cranking path
    - Length of cranking path (travel time, number of substations)
    - Staffing availability (field/control room) to support building cranking path to neighboring area
    - SCADA versus Manual control
  - Logistical coordination
    - Adjacent TO zones only (do not cross 3 or more zones)
    - Type of load restored in each TO zone
    - Potential additional TO costs incurred to enable cross zonal coordination
    - Number of TO zones in coordination with a single TO zone

- TO/State Relationship considerations
  - States may want priority of restoration to remain local

- Cost Savings
  - For a choice between BS unit inside zone versus BS unit outside zone
    - Minimum threshold of either $1 million in savings in total capital cost OR $198,000 in savings in Unit Total Annual Revenue Requirements
• The Total Annual Revenue Requirement savings is calculated using the Total Capital Cost savings times the CFR factor (from Schedule 6A) for an average 10 Year Recovery. (i.e. $1,000,000 * 0.198 = $198,000)

• If this cost savings criteria is met, TO would not have option to refuse unless they “opt out” of cross zonal unit selection
  o Consider opportunities for savings less than these thresholds, but only implement if all involved parties agree
    — Shortages/Surplus of Black Start resources
    — Transmission topology
    — Geography
    — Operational considerations
      - Increased efficiency
      - Increase in speed of restoration
      - Reduce cost (order of magnitude; significant savings)

There are three possible levels of Cross Zonal Coordination:

**Level 1** – Supply Black Start from outside TO zone to meet TO critical load requirements
- This would be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).
- Restoration Plans would be on a TO basis, but coordinated between TOs.
- PJM would work with TO to identify these situations
- Redundancy on a TO zonal basis (2 BS units allocated to each TO zone, though physically may be outside zone)
- If PJM and TO disagree on selection of Black Start units, TO has several options:
  o Acquire additional Black Start outside of PJM OATT
  o “Opt out” of PJM Black Start selection and acquire their own Black Start outside of OATT
  o Enter Dispute Resolution Process

**Level 2** – In collaboration with TOs, identify opportunities to supply critical load and/or customer load pockets across TO zones
- This could be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).
- A single Black Start unit may serve critical load in multiple TO zones
- Restoration Plans would be on a TO basis, but coordinated between TOs.
- Redundancy would be on a TO basis (2 BS units allocated to each zone, though physically may be outside zone)
- If these opportunities are to meet reliability requirements, they would be required.
- If the Level 2 cross zonal coordination is only to increase efficiency, speed or reduce cost, then any involved TO may refuse these coordination opportunities with justification.

**Level 3** – In collaboration with TOs, Identify opportunities to fully aggregate TO Restoration Plans
- This could be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).
- This could be merging of 2 or more existing TO zones or creating new Restoration Regions (new boundaries).
- Restoration plan would be for aggregated area(s).
- Redundancy would be evaluated on a Restoration region basis.
- Any affected TO and PJM would have to agree to this type of aggregation. If not all affected TOs and PJM do not agree, the aggregation will not occur.

**Design Component #4 – Entity responsible for Black Start location**

PJM, in its role as Transmission Operator (TOP), is responsible for selecting the Black Start resources for a System Restoration plan. PJM would work closely with the TOs to identify these units based on:
- Critical Load requirements
- Available Black Start resources
- Minimum number of Black Start resources allocated to a zone
- Possible cross zonal coordination opportunities

Should there be a disagreement about the location, amount, and number of Black Start resources; PJM has the final decision on selection of these resources. The TO should adjust its System Restoration plan based on the Black Start units allocated to it from this selection process. The TO has the option of procuring additional Black Start resources (if not already procured by PJM), but the costs of these resources will be recovered, if necessary, outside of the PJM Open Access Transmission Tariff (OATT).

If TO does not agree with PJM’s selection of BS units, TO can opt out of Selection process and acquire additional or different BS resources through bilateral contracts. This will occur outside the PJM OATT. Costs will not be collected or distributed through PJM’s Tariff. TO must provide PJM evidence that the BS selected and contracted by the TO will meet all of the PJM reliability criteria.
Design Component #4 and #5 – Tiered approach to Black Start

PJM recommends revising the current requirement of 90 minute start time for Black Start resources to a four hour or less start time requirement.

This change would recognize the changing generation landscape and allow for the potential for more Black Start resources to be recognized in System Restoration planning. This simple change could allow up to an additional 70,000 MW of resources to potentially supply Black Start. It is estimated that about 2,000 MW of this could supply Black Start with no plant modifications. PJM would allow exceptions to this four hour criteria on a selected basis if it benefits the System Restoration plan.

PJM will utilize the start time parameters and test data to evaluate the Black Start resources and whether these resources will meet the requirements of the restoration plans. PJM may require some Black Start resources to adhere to less than a 4 hour start time given critical load restoration timing requirements. These units will be notified of this timing requirement and tested to it during annual Black Start testing. PJM recognizes that Black Start resources with four hour start times are not appropriate to meet nuclear power off-site safe-shutdown load restoration requirements. PJM will retain the 4 hour time target for restoration of off-site power to nuclear stations.

Design Component #8 – Amount of Black Start MW required

PJM proposes redefining the existing definition of Critical Load to the following:

Critical Load is the sum of the following components:
- a) Cranking power to all units with a hot start time four hours or less
- b) Off-site Nuclear Station Light and Power
- c) Critical Gas Infrastructure

The prominent change from the existing Critical Load definition is in component (a). The current definition is “cranking power to critical steam units with a hot start time of 8 hours or less”. The change was to include the cranking power for ALL units (not just steam) and change the start time to a hot start time of four hours or less.

The justification for this change is to target the use of the cranking power to any unit that can start in four hours or less. PJM estimates that this is about 70,000 MW of capacity. This is more generation capacity than could be utilized in the early stages of a System Restoration. Once this “four hour” generation is online, it can be used to supply the cranking power to units with longer than a four hour start time.

Required Black Start = 110% (Critical Load requirement) on a locational basis

This requirement reflects the redundancy proposed in Design Component #2. It is recognized that while this requirement is specified on a TO zonal basis, that zones may be aggregated, as described in Design Component #3, such that the Black Start
resources may physically lie in adjacent zones. Exceptions to this Black Start requirement will be allowed with PJM and SOS-T approval.

Design Component – Procurement Option

**PJM recommends a 5 year Selection Process for Black Start Generation procurement.** Every 5 years, PJM issues an RFP for Black Start generation. This RPF would be open to all existing and potential new Black Start units on a voluntary basis. PJM will select units on the basis of Critical Load requirements, location, cost and operational considerations (amount, start time, etc). Length of commitment would be a minimum of 2 years (or longer based on capital recovery time). Compensation for units not electing to recover black start capital costs is based on the PJM OATT Schedule 6A formula rate. Compensation for units electing to recover black start capital costs would be based on the PJM OATT Schedule 6A Capital Recovery Rate based on age of the unit. RPM Revenues will be netted from the Black Start Compensation for units that are Refurbished or new units constructed using the PJM OATT Schedule 6A Capital Recovery Rate.

Design Component – Incremental Procurement

**PJM recommends retention of the existing RFP process with added flexibility.** Upon Black Start resource notice of termination (requiring a one year notice); PJM will work with the TOs to identify if replacement Black Start is required. PJM will evaluate if existing Black Start from outside the zone or refurbishment of existing units within the zone may be utilized to meet the requirement. If required, PJM will issue an RFP to procure this Black Start. If no resources or not enough resources are procured, PJM will expand the geographic scope or MW amounts of the RFP and re-issue. If still no resources are procured, PJM will utilize the Reliability Backstop option, if required.

Design Component – Reliability Backstop

**PJM recommends a Reliability Backstop option.**

Triggers for the Reliability Backstop:
- 2 failed incremental RFPs – no technical solution available even after consideration of cross zonal coordination options
- Technically feasible solution available, but not economically feasible (not in accordance with OATT rate or FERC rate is rejected)
- Reliability criteria not met in 5 year Selection process in one or more areas

Allow Reliability criteria exceptions for the following situations:
- Black Start capacity less than Critical Load Requirement
- Less than 2 Black Start units per zone (or Restoration region if aggregated)
- Critical Gas Infrastructure load restoration longer than 4 hours
- Nuclear safe shutdown load restoration longer than 4 hours

These exceptions would request (but not require) SOS-T endorsement.

If the following Reliability criteria is violated, other options would be pursued:
- NPIR requirements violated
- No Black Start generation allocated to a zone that has a critical load requirement

Other options that will be pursued:
- RTEP Transmission only solution such as new transmission line for cranking path, reactor, SVC, etc
- Work with generators in Interconnection queue to install Black Start capability
- Work with TO to contract for Black Start

If all methods fail:
- Deficient zone will receive cranking power from neighboring zones
  - This cranking power will NOT be from a Black Start unit and will likely not be available for many hours
  - Based on M-36, Section 8.1.9, cranking power must be supplied to neighboring areas as a priority to restoring internal load
- **AREAS OF GENERAL STAKEHOLDER AGREEMENT**

**Design Component #9 – Initial Restoration Plan Assumptions**

PJM recommends retaining the existing restoration plan assumption of a complete blackout with no outside assistance available (i.e. bottom up restoration).

**Design Component #10 – Initial Restoration Assumptions (Weather/Load)**

PJM recommends retaining existing restoration plan assumptions. These assumptions include:
- Normal weather pattern
- Intermediate to Peak load levels
- Minimal equipment damage
- Adequate staffing available

**Design Component #16 – Scenarios in Restoration Drills**

PJM recommends planning for worst case scenario (Design Component #9), but focus training and analysis on a variety of scenarios.

**Design Component #12 – Area for Restoration Assumption**

PJM recommends M-36 continue to define common elements and guideline for TO restoration plans. TO restoration plans will be coordinated or aggregated based on results of analysis of benefits of aggregation as described above in Design Component #3.

**Design Component #13 – Responsibility for Restoration and Coordination**

PJM recommends retaining the existing paradigm; Implementation of a System Restoration is performed at a TO zonal level with PJM coordination of area interconnection and restoration of the EHV system restoration.

**Design Component #14 – Maximum Number of Black Start Units at one site.**

PJM recommends removal of this business rule. This would allow more than three Black Start units at a generating plant to provide Black Start.

**Design Component #15 – Cross-zonal Black Start Addressed**

PJM recommends that System Restoration plans remain TO-based except in cases where plans have been aggregated into regions. In these cases, plans...
must reflect responsibility of each TO operator in the aggregated plans, or at a minimum, coordinate the TO-based System Restoration plans to reflect the larger, regional approach.

**Design Component #17 – Units Eligible to be Black Start**

**PJM recommends that any unit capable of meeting the requirements of a Black Start unit should be eligible for consideration in System Restoration planning.** This would include the revision of Black Start start-up time to four hours. It would also not preclude new technologies (renewable, mobile Black Start) from participating as Black Start generators if these resources can meet the established criteria.

**Design Component #18 – TOs may optionally procure additional BS through bilateral contracts outside PJM OATT.**

**PJM recommends inclusion of the option for TOs to optionally procure additional Black Start capability (above PJM procurement).** This additional Black Start would not be compensated through the PJM OATT. Terms of these procurements would be between the TO and Black Start resource owner.

**Design Component #19 – Reactive and Voltage Concerns addressed**

**PJM will ensure reactive and voltage concerns were addressed based on testing and simulations.** This is required at least every 5 years in accordance with NERC Standard EOP-005-2 R6.

**Design Component #20 - Cranking Path Issues Addressed**

**PJM will ensure cranking path viability based on studies and simulations.** This is required at least every 5 years in accordance with NERC Standard EOP-005-2 R6.

**Design Component #21 – Fuel Reliability/Fuel Diversity Addressed**

**PJM recommends an analysis to ensure fuel and gas pipeline diversity is considered during Black Start unit selection.**